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(71) Applicants
Nord-Micro Electronik
Feinmechanik AG, Victor-
Slotosch-Strasse 20,
D—6000 Frankfurt/Main
60, Federal Republic of
Germany
(72) Inventors
Bernd Ohnesorge,
Günther Väth
(74) Agents
D. Young & Co.

(54) Transferring power and signals in opposite directions

(57) A process and apparatus for transmitting a pulse measuring signal from a sensor 26 in one direction as via windings 18, 20 and a pulse-form supply current in the other direction as via windings 12, 13.

A preferred use is as a device wherein the supply current and the measuring signal are transmitted between a stationary component of an apparatus and a rotatable component of an apparatus, by means of a rotary transmitter, circuit portion 22 being on the rotatable component.

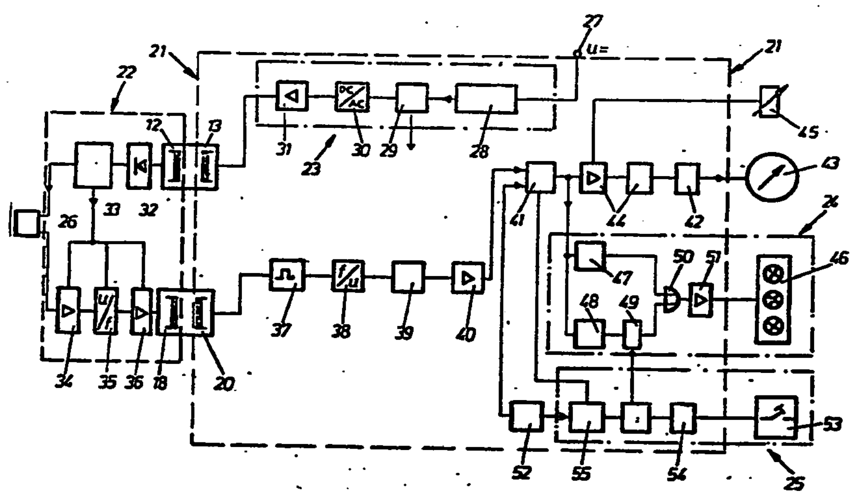

Fig.2

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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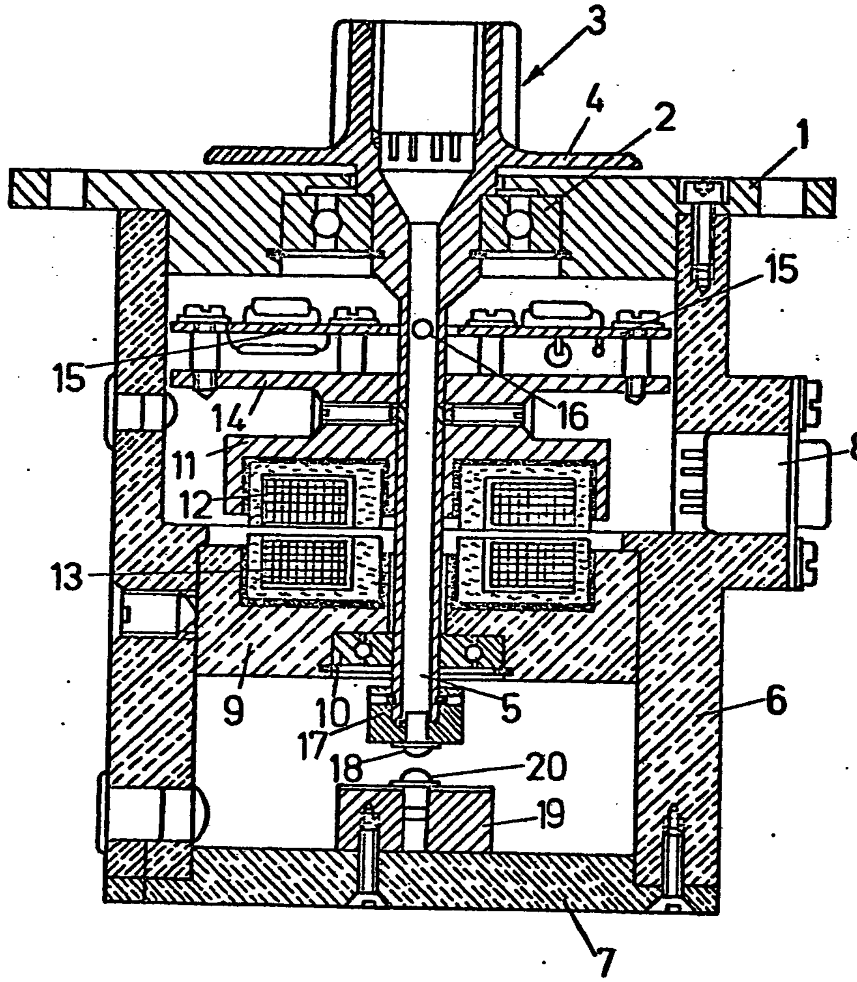
Fig.1



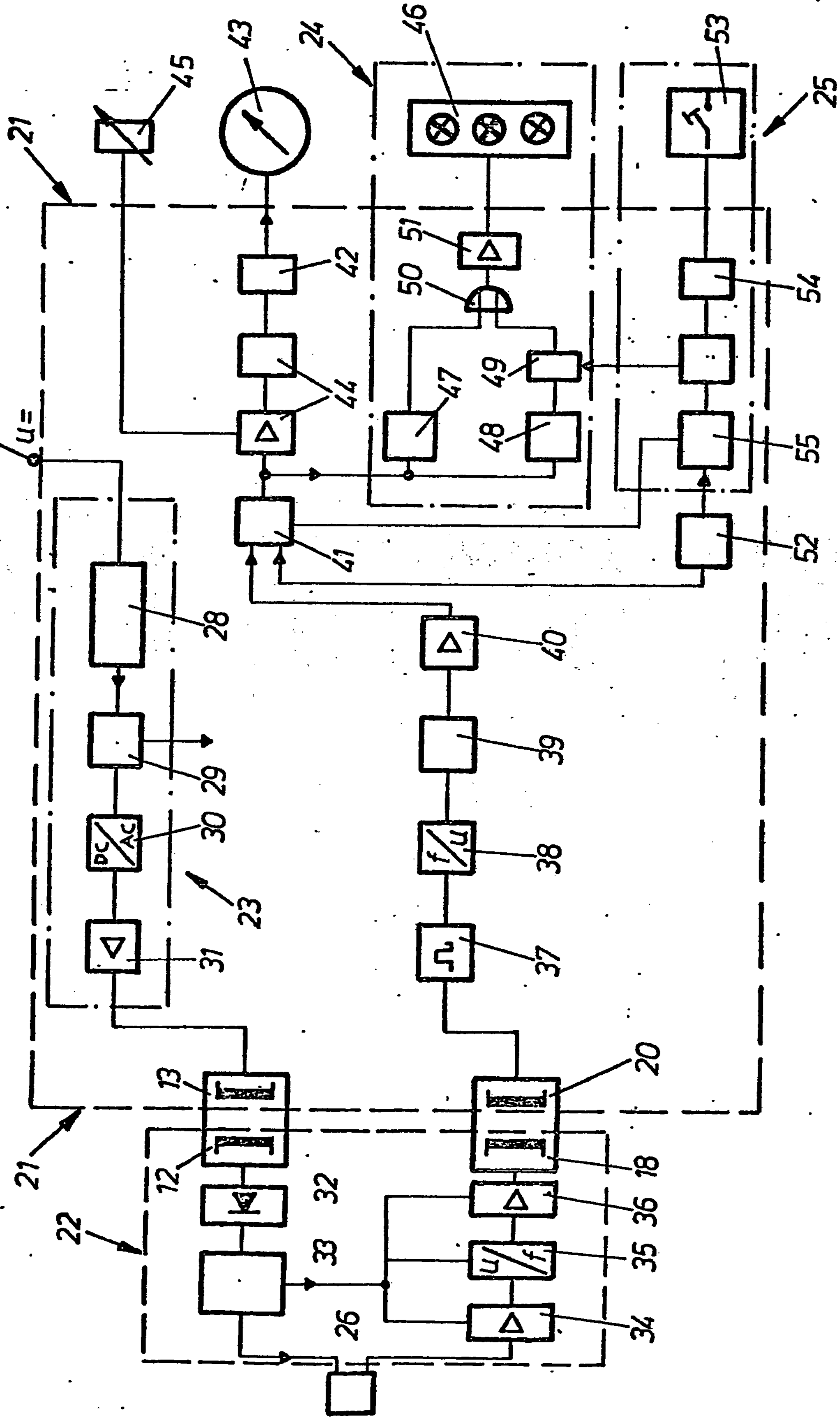

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Fig.2

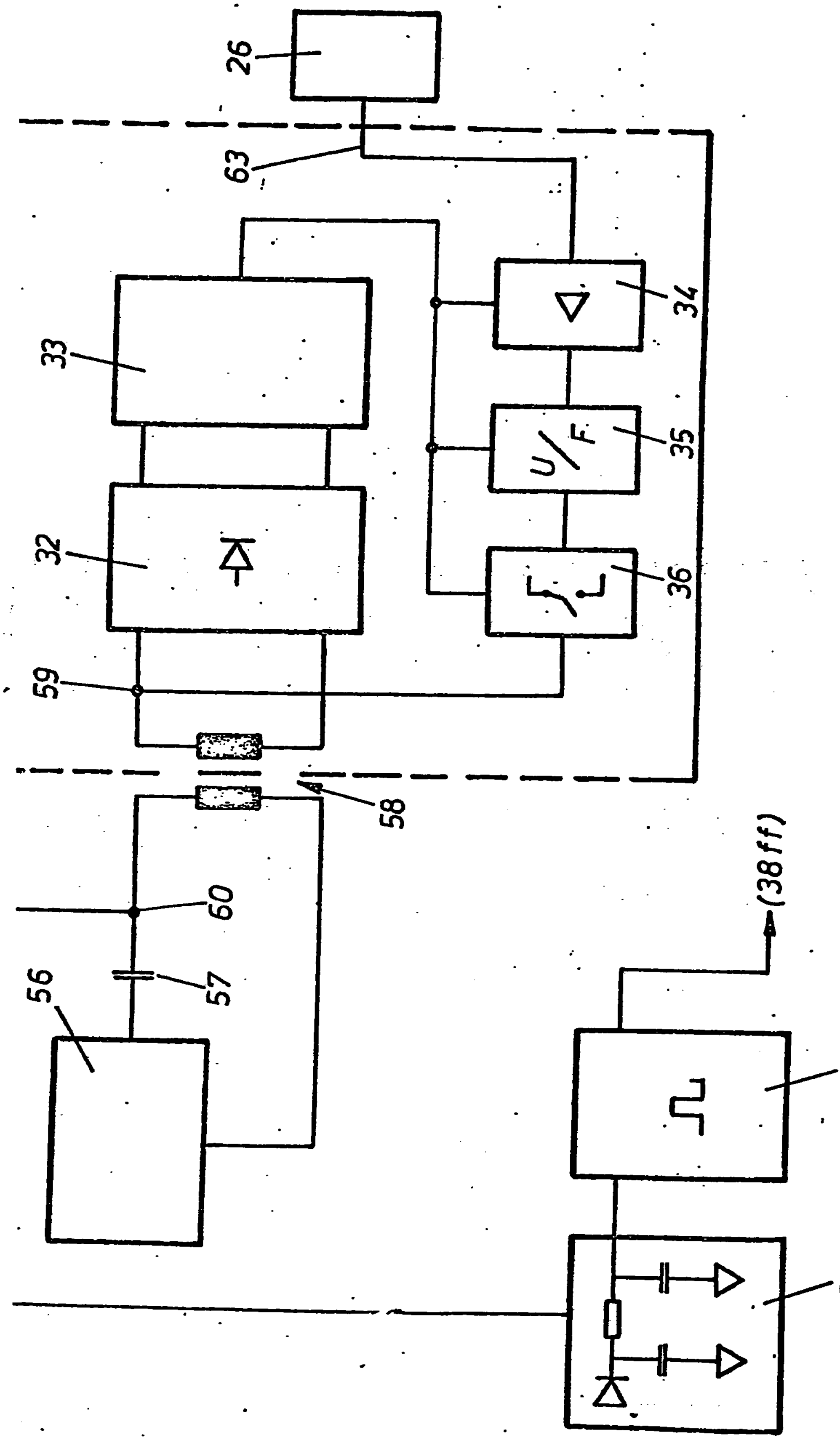

Fig.3

SPECIFICATION

Process and apparatus for transmitting measuring signals in pulse form by way of a transmitter arrangement

The invention relates to a process and apparatus for transmitting measuring signals in pulse form by way of a transmitter arrangement.

Such a transmission assembly is not readily suitable for fine measurement under rough operating conditions. It should be noted that many rotary machine components suffer from natural vibration movement, in particular rotary vibration movements, which, when using inductive transmission, simulate fluctations in the measurement value which in actual fact do not exist.

According to the invention the pulses of the measuring signal produce a defined change in the terminal impedance of the primary winding, which change produces at the secondary winding a corresponding change in the electrical conditions, which is used specifically for transmission of the information signal.

For reliably transmitting the supply current, an embodiment of the invention provides that the supply current used in an alternating current, and that, to the secondary side of the corresponding transmitter, it is connected to a means for rectification and for precise voltage stabilisation, which means supplies at least one measurement value transmitter.

Reliability in the transmission of the measurement values is particularly ensured by the measuring signal or signals being fed to a means for conversion into a pulse form which is proportional to the measurement value, for example a frequency, and for the pulse form to be fed to the transmitter for the measuring signal.

In order further to enhance the reliability of transmission, an embodiment of the invention provides that the circuit arrangement for measurement value processing has associated therewith an arrangement which can be selectively switched on, for testing its operational reliability.

The invention is described in greater detail hereinafter by way of example with reference to the drawing, in which:

Figure 1 shows a view in cross-section of a transmitter arrangement.

Figure 2 shows a block circuit diagram for describing the invention, and

Figure 3 shows a block circuit diagram of an embodiment of the invention.

Secured to a stationary machine component (not shown) is a mounting flange 1 in which a rotary machine component, in this case a shaft 3, is mounted by means of a ball bearing assembly 2, the rotary machine component being mounted as close as possible to the end of the shaft 3 in order to absorb vibrations or oscillations of the shaft.

The bearing clearance is covered by means of a flange 4 which is fixedly connected to the shaft 3.

The shaft 3 has a tubular extension portion 5. A cylindrical housing 6 is fixedly connected to the flange 1 and is closed by means of a bottom end plate 7. The housing 6 fully sealingly encloses the end of the shaft and carries a connection plug 8 for the electrical connections. A portion 5 of the shaft projects through a further mounting flange 9 in which it is mounted by means of a ball bearing assembly 10.

The portion 5 carries an annular flange 11 to which one transmitter member 12 which rotates with the shaft is secured. The other transmitter member 13 is fixedly connected to the flange 9. A plate-shaped member 14 which is connected to the annular flange 11 and which rotates with the shaft 3 carries modular plates 15 which carry the circuit members which serve to provide current supply for a measurement value transmitter and for converting the measurement value signals.

The transmitter formed by the members 12 and 13 provides in the embodiment illustrated for the supply of current or voltage for the measuring device (not shown) or a plurality of such devices. The feed lines to the measuring device are taken from the corresponding plates 15 through the interior of the shaft 3, for example through openings 16 in the wall of the portion 5 of the shaft. The transmitter which serves to return the measuring signals could be arranged concentrically relative to that shown. However, in order as far as possible to exclude fluctuations in the signal level, an optical-electrical transmitter is provided for ensuring measurement value transmission.

For this purpose, a holding ring 17 is arranged adjustably and centrally at the end of the portion 5. At a central position, the ring 7 carries a light-emitting member 18, for example a light-emitting diode.

A block 19 is adjustably mounted on the end plate 7 of the housing 6 and carries a light-sensitive member 20. The block 19 is adjusted in such a way that there is no eccentricity as between the photoelectric members 18 and 20 when the shaft 3 rotates, which could cause fluctuations in the signal level. The member 18 is connected by way of supply lines to the plates 15, while the member 20 is connected by way of supply lines to the plug 8.

The circuit arrangement is shown in Figure 2 in the form of a block circuit diagram.

The circuit arrangement includes a stationary portion 21 and a portion 22 which is connected to the rotating machine component. The transmitter members are denoted by the same reference numerals as those used in Figure 1.

The first circuit portion 21 includes a current supply unit 13, a measurement value preparation unit, a measurement value evaluation unit 24, and a checking or testing unit 25.

The second circuit portion 22 also includes, in addition to at least one measurement value transmitter 26, a supply unit and a unit for preparing the measuring signals.

The voltage applied to the device by way of a plug 27 is firstly passed by way of a filter 28 with

an interference voltage peak suppression means connected to the output thereof, the feed voltage being converted in a stabilisation circuit 29 to the voltage required for operating the electronic arrangements. A circuit for limiting the cut-in and working current and a buffer network for compensating for interruptions in voltage are also a part of the voltage supply arrangement but are not shown.

The DC/AC-converter 30 which follows the stabilising circuit 29 operates on a driver circuit 31 which supplies the power required for inductive coupling in.

The rotary transmitter 13, 12 represents the connecting means between the rotating and the stationary components of the apparatus. The main part of the connecting means is formed by two phase transformers which are provided on the one hand to couple the supply voltage inductively into the rotating shaft, and on the other hand to take the measuring signal inductively from the shaft to the stator member (18, 20). This method of inductive coupling permits contact-free and wear-free transmission when the rotor is stationary and when the rotor is moving.

The phase transformer comprises two halves 12 and 13 which are separated by an air gap. The primary-side winding 13 of the transformer is disposed in a shell core which is mechanically fixed to the housing. The winding and the core are of a rotationally symmetrical construction, thereby achieving a minimum of amplitude modulation. The secondary portion 12 of the phase transformer is fixedly mounted on the drive shaft and corresponds in construction and dimensions to the primary portion. The cores are installed in such a way that the open sides lie opposite each other and are separated only by an adjustable air gap. The connections of the secondary winding are taken to one of the plates 15 which rotate with the drive shaft. The plate 15 carries a rectifier circuit 32 with a stabilisation module 33 connected to the output thereof. This supplies the voltage supply for the measurement value transmitter and the remaining circuits, which voltage is taken by way of cables in the shaft 3 which is in the form of a hollow shaft, to a plug connection for connection of the measurement value transmitter 26.

The measurement value transmitter supplies for example a voltage which is proportional to the available measurement value and whose frequency is dependent on the measurement parameter. The voltage at that point is passed by way of an amplifier 34 and a voltage-to-frequency converter 35 with a driver 36 connected to the output thereof, in the form of a rectangular voltage, to the primary side 18 of the second phase transformer.

The supply of voltage is effected through the hollow shaft 3 with inductive coupling therefrom to the stator portion.

The signal from the secondary winding 20 of the signal transmitter is firstly prepared in a pulse shaper stage 37 and converted back into an analog voltage in a frequency-to-voltage converter 38. The signal at that point again has the characteristic of the voltage which was taken off at the measurement value transmitter.

The oscillating voltage of which only the peak value is of interest to the present case, is detected in a peak value measurement circuit 39 and stored. When the measuring operation is a continuous operation, a respective DC voltage corresponding to the present measurement value is available at the circuit output, for the duration of half a revolution of the rotor. A matching circuit 40 forms the output stage of the signal preparation portion of the circuit arrangement.

The circuit includes an analog switching means 41 for feeding the measurement voltage which has been converted back into an analog voltage, to an adjustment control circuit, in order to act as a control parameter. The control circuit includes a servo motor 42 with position repeating means, and suitable networks for frequency characteristic correction. Display is effected by the pointer of the display device 43, the pointer being fitted directly on the motor shaft.

Using a high-quality servo circuit, besides giving highly accurate display, also provides substantial insensitivity with respect to the relative position of the display device, in particular rotary vibration or oscillation movements in the longitudinal direction of the axis of the pointer, and also vibration movements. The control parameter is supplied to the control circuit by way of a limiting circuit 44 by way of an adjustable transmitter 45 which limits the maximum pointer deflection to about 110%.

The input voltage for the servo circuit is used at the same time for actuating the warning display means 46. A first comparator 47 provides a suitable output signal when a predetermined limit value is exceeded, the display signal disappearing again when the value falls below the predetermined limit. A further comparator 48 provides an output signal when another limit value is exceeded, and at the same time activates a holding circuit 49. The warning display 46 is activated by way of an OR-gate 50 with a driver 51 connected to the output thereof.

In the view shown in Figure 1, the phase transformer for taking off the measuring signal is replaced by a light-emitting diode (LED) 18 which operates in the infra-red range, and a suitable photoelectric transistor 20. Apart from different dimensions and matching of the driver stage on the rotating portion of the pulse shaper in the display device, no changes are required for this purpose in the electronic part of the apparatus.

The mechanical structure of the phase transformer is considerably simplified by changing over to an optical transmission assembly.

As can be seen from Figure 1, the diode is disposed in a holder, being positioned centrally on the free end of the shaft. Opposite, disposed on the stator portion, is the receiver which is also positioned centrally at a small distance. The spacing between the two components and the

positioning thereof are relatively uncritical with the above-described structure, as the pulse shaper connected to the output thereof reliably compensates for changes in amplitude due to a variation in the spacing or modulation due to slightly eccentric positioning.

In addition to reducing the amount of mechanism involved, the above-described arrangement can also provide for a reduction in weight and height.

By virtue of the fully encapsulated construction, the transmission path is substantially protected from extraneous light and fouling.

A stabilised generator 52 supplies a reference frequency for signal evaluation.

Satisfactory functioning of the measurement value evaluation means 24 can be checked by means of the testing unit 25. When a button 53 is pressed, a test signal is produced in a unit 54, which corresponds to a given limit value in respect of the measuring signal. At the same time, a switch-over signal is produced in a unit 55. These signals are applied respectively to the holding circuit 49 and the analog switching means 46. The display at the display device 43 and at the warning displays 46 must now coincide with the pre-programmed testing value.

As shown in Figure 3, the invention provides a construction which affords particular advantages in certain use situations.

In this embodiment, instead of the two transmitters 20 and 21 of Figure 2, there is only a single transmitter 58. The supply current at relatively high frequency for the measuring sensor 26 is provided by a power oscillator 56 which is coupled by way of a capacitor 57 to one winding of the transmitter 58. The other winding of the transmitter feeds a rectifier 32 which is connected to a stabiliser 33, as in the embodiment of Figure 2. The stabiliser feeds members 34—36 as shown in Figure 2.

The measuring signal which was produced for transmission by the circuit arrangements 34—36 is a signal which has a frequency that is proportional to the measurement value, that is to say, which is derived therefrom by way of a given function. This signal is coupled into the circuit at point 59, passed by way of the transmitter, and taken from the circuit at the other side of the transmitter, at point 60. The signal is applied to a demodulator 61 and a comparator 62 and then to the above-mentioned evaluation circuit shown in Figure 2.

In the circuit arrangement illustrated, the frequency of the measuring signal is used to produce a corresponding rhythmic change in load on the rotating side of the transmitter. This change in load in turn also causes a change in load on the stator side of the transmitter. On this side of the transmitter, the supply current is produced by means of a power oscillator whose low output impedance however virtually eliminates the measuring signal. The measuring signal is therefore taken out of the circuit at the point 60 which is to be considered as being of high resistance, between the capacitor 57 and the transmitter coil, where it occurs in the form of a frequency which is proportional to the measurement value. The measuring signal is therefore virtually reflected from the rotor side on to the stator side.

It is desirable for the frequencies of the supply current and the measuring signal to be sufficiently far apart in order to ensure that the two signals are cleanly decoupled.

When the air gap in the transmitter changes, only the amplitude of the signals but not their frequency is impaired. Stabilisation on the rotor side provides that there is no change in the supply voltage when the air gap changes within given tolerance limits.

The measuring signal at point 60 is separated from the frequency of the supply current in the demodulator 61 and converted in the comparator 62 to a signal comprising rectangular or square pulses. The above-described circuit arrangement makes it possible to manage with one line for the transmission of supply current and measuring signal, and this further reduces the susceptibility to trouble of the whole of the apparatus. In addition, a plurality of measuring signals can be transmitted simultaneously on a plurality of channels.

The transmitter windings can be galvanically connected or also separated.

With regard to the transmitter arrangement, any suitable permeable material can be used for making the magnetic core, that is to say, not only solid materials but also gases, fluids or combinations thereof.

An arrangement according to the invention is of fully universal utility. As mentioned above, the electrical design of the arrangement is designed for rough operating conditions, as for example in a vehicle or a flying machine. Thus, the arrangement can be used for example for continuously monitoring the mast or pylon moment of a helicopter rotor.

CLAIMS

1. A process for transmitting a pulse measuring signal by way of a transmitter in one direction and a pulse supply current in the other direction, wherein the pulses of the measuring signal produce a defined change in the terminal impedance of the primary winding, which at the secondary winding produces a corresponding change in the electrical conditions, which is used specifically for transmitting the information signal.

2. A process according to claim 1 wherein the transmitter is a rotary phase transmitter.

3. A process according to claim 1 or 2 wherein the measuring signal or signals are supplied to a means for conversion into a pulse form proportional to the measurement value, for example a frequency, and said pulse form is supplied to the transmitter for the measurement signal.

4. A process according to any one of the preceding claims wherein a first frequency band is

used for transmitting information signals and a frequency different from said frequency band is used for transmitting a supply voltage or a supply current in the opposite direction by way of the same windings of the transmitter.

5. A process according to any one of the preceding claims wherein the supply current is transmitted at a frequency which is a multiple of the measuring signal.

6. A process according to claim 4 wherein a power oscillator of low output impedance which eliminates the information signal is used to produce a supply current, and the information signal is taken out of the circuit at a high-resistance point between the oscillator and the secondary side of the transmitter.

7. A process according to any one of the preceding claims wherein the measuring signal is taken off between the transmitter and the capacitor and is supplied by way of a demodulator to the evaluation circuit.

8. A process according to any one of the preceding claims wherein the supply current is an alternating current which is supplied to the secondary side of the corresponding transmitter to a means for rectification and for precise voltage stabilisation, which supplies at least one measurement value transmitter.

9. A process according to any one of the preceding claims, for transmission between two machine components which are relatively rotatable with respect to each other, wherein one and the same line is used for the transmission of supply current and measuring signal on the rotatable machine component.

10. Apparatus for carrying out a process according to any one of the preceding claims wherein a power oscillator of low output impedance which is coupled to the transmitter by way of a capacitor is provided for producing the supply current.

11. Apparatus according to claim 11 wherein the measuring signal is coupled in between the transmitter and a rectifier which receives the supply current and which supplies a measuring sensor by way of a stabiliser.

12. Apparatus according to claim 10 or 11 wherein the transmitter is in the form of a ring-type transformer.

13. Apparatus according to any of claims 10 to 12 wherein a downstream circuit arrangement for measurement value processing includes comparators for controlling the display of selected limit values.

14. Apparatus according to any of claims 10 to 13 wherein the circuit arrangement for measurement value processing has associated therewith an arrangement which can be selectively switched on, for testing its operating reliability.

15. A process for transmitting a pulse measuring signal by way of a transmitter in one direction and a pulse supply current in the other direction substantially as hereinbefore described with reference to the accompanying drawings.

16. Apparatus for transmitting a pulse measuring signal by way of a transmitter in one direction and a pulse supply current in the other direction constructed and arranged substantially as hereinbefore described and shown in the accompanying drawings.

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